NAVAL POSTGRADUATE SCHOOL
Monterey, California

EC 3550 FINAL EXAM 12/87Po

- This exam is open book and notes.
- There are four problems; each is equally weighted.
- Partial credit will be given; be sure to do some work on each problem.
- Be sure to include units in your answers.
- Please circle or underline your answers.
- Show *ALL* work.

1	
2	
3	
4	
Total	

Name: _____

Data about fibers and devices are found in the attached tables.

1. Detector #2 is used in a link with Source #2. The total link losses are 20 dB. The detector is connected to a 50 Ω load resistor in parallel with a amplifier that has a 50 Ω input resistance and a 5 pF input capacitance. The overall gain of the amplifier is 1000 volts/amp. The thermal noise associated with the input resistance is the dominant noise source of the amplifier. Other noise mechanisms are negligible. The thermal noise temperature is $T = 300K$.

   Calculate the optimum value of M for the detector.

2. Source #3 is connected to 5 km of Fiber #2. The loss per connector due to all misalignments is 1.5 dB. Index matching gel is *not* used in the connector. Calculate the power ($in\ \mu W$) at the far end of the fiber.

3. A 25 Mb/s link uses Source #1 with Fiber #1. The fractional change in the index of refraction of the fiber is $\Delta = 0.951\%$. The link is to use non-return-to-zero coding.

   - Calculate the maximum link distance ($in\ km$) if the link is limited by modal dispersion.
   - Calculate the maximum link distance ($in\ km$) if the link is limited by material dispersion.

4. Source #2 is to be used in a 50 Mb/s link (NRZ coding) with Detector #2 operated with $M = 1$. The total losses of the link are 28.6 dB. Assuming that the detector performance is limited by the shot noise associated with the detector dark current of 10 μA, find the expected bit error rate of the link. Assume that the 50 Mb/s data rate requires a bandwidth of 110 MHz.

FIBER SPECIFICATIONS

	Fiber #1	Fiber #2	Fiber #3
Size	50/125	62.5/125	8/125
g	2	∞	∞
NA	0.20 (at $r = 0$)	0.20	0.10
α @ 820 nm	5.0 dB/km	6.0 dB/km	2.0 dB/km
α @ 1300 nm	1.0 dB/km	1.20 dB/km	0.5 dB/km

SOURCE SPECIFICATIONS

	Laser #1	Laser #2	LED #3
Wavelength	820 nm	1300 nm	820 nm
$\Delta\lambda$	1 nm	2 nm	50 nm
Power at pigtail end	500 μW	500 μW	5 μW
Pigtail size	200/300 μm	10/125 μm	200/300 μm
Pigtail NA	0.25	0.12	0.25
Pigtail type	Step index	Step index	Step index

DETECTOR SPECIFICATIONS

	Detector #1	Detector #2
Material	Silicon	Germanium
Responsivity A/W @ $M = 1$	0.8 @ 820 nm	0.2 @ 1300 nm
C_d	3 pF	1 pF
Excess noise factor	$M^{0.3}$	M^{1}
Bulk dark current	10 pA	10 μA
Surface dark current	0	0